

Often used graph representations

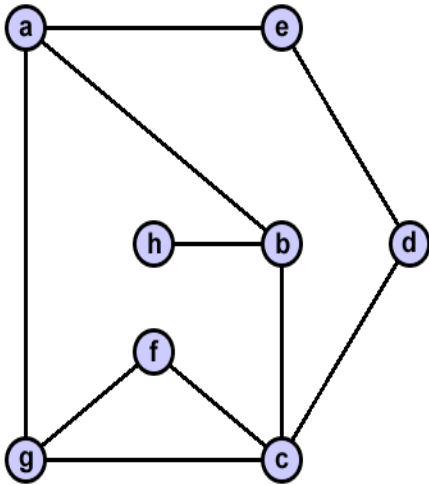
V - number of vertices (nodes), E - number of edges

Edge array - size: E

Adjacency matrix - size: $V * V$

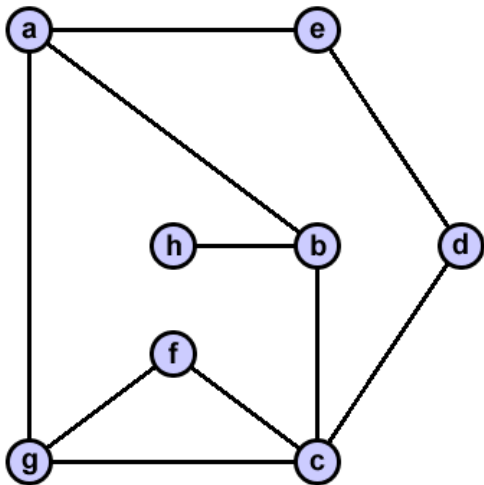
“pure” representations

Adjacency matrix



	a	b	c	d	e	f	g	h
a	0	1	0	0	1	0	1	0
b	1	0	1	0	0	0	0	1
c	0	1	0	1	0	1	1	0
d	0	0	1	0	1	0	0	0
e	1	0	0	1	0	0	0	0
f	0	0	1	0	0	0	1	0
g	1	0	1	0	0	0	0	0
h	0	1	0	0	0	0	0	0

Edge Array



a b

a e

a g

b c

b h

c d

c f

c g

d e

f g

Representation properties

V - number of vertices

E - number of edges

	matrix	edge array
space	V^2	E
find edge	1	E
insert edge	1	1
path v to w ?	V^2	$E \lg V$

The matrix representation is useful in calculation of many network properties, e.g. the number of paths of a given length between two nodes, path-based centrality measures, but it is very memory-extensive for large graphs.

Graph processing software tools

- **GUI programs:** Pajek, yED, UCINET, BioTapestry
- **Command line programs:** graphviz, R, statnet
- **Software Libraries:** LEDA, networkx, igraph

- **Input:** user input (mouse-clicks) or files
- Most file formats are text, graph formats
- **Output:** images or data files
- **Focus:** visualization or graph algorithms

Graphviz

command line graph visualizer – the language itself is called **dot**



About

[Download](#)

[News](#)

[Gallery](#)

[Documentation](#)

[Theory](#)

[Bugs](#)

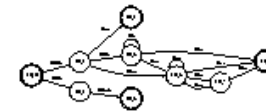
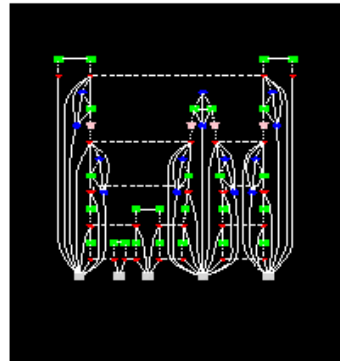
[MailingList](#)

[License](#)

[Resources](#)

[Credits](#)

Graphviz - Graph Visualization Software



Graph Visualization

Graph visualization is a way of representing structural information as diagrams of abstract graphs and networks. Automatic graph drawing has many important applications in software engineering, database and web design, networking, and in visual interfaces for many other domains.

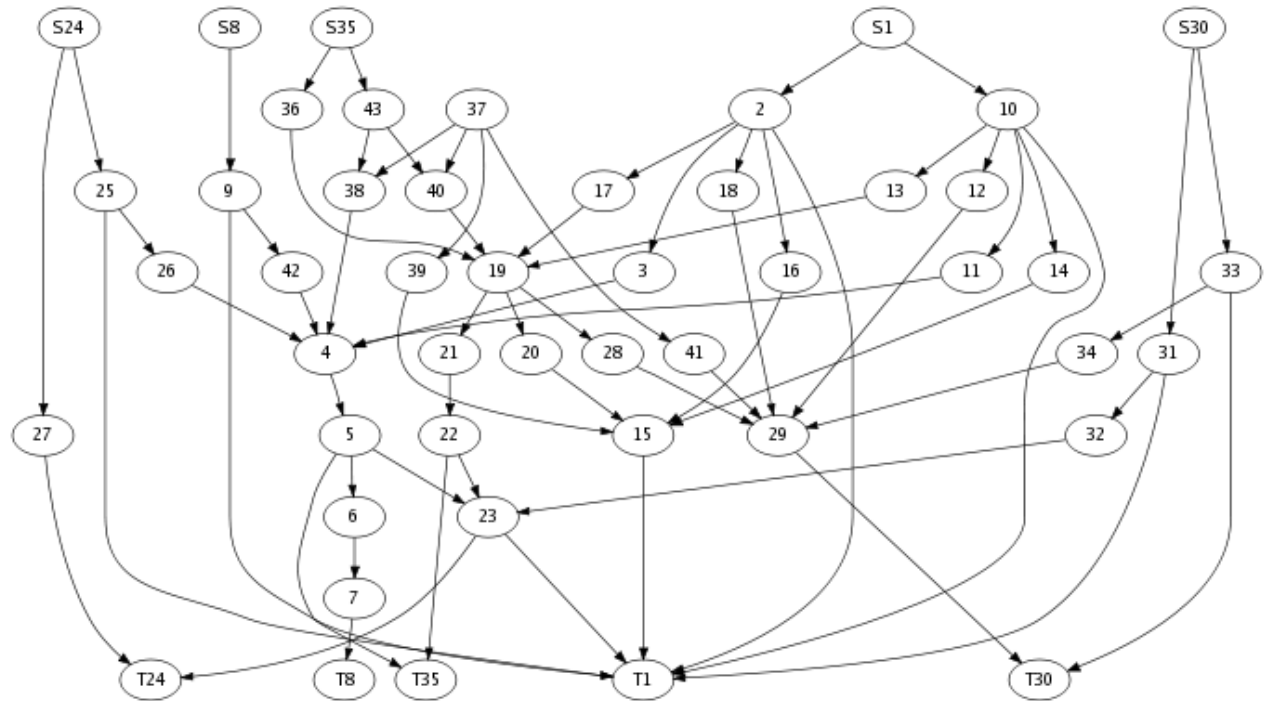
Graphviz is open source graph visualization software. It has several main graph layout programs. See the [gallery](#) for some sample layouts. It also has web and interactive graphical interfaces, and auxiliary tools, libraries, and language bindings.

The [Mac OS X edition of Graphviz](#), by Glen Low, won two 2004 Apple Design Awards.

Graphviz example

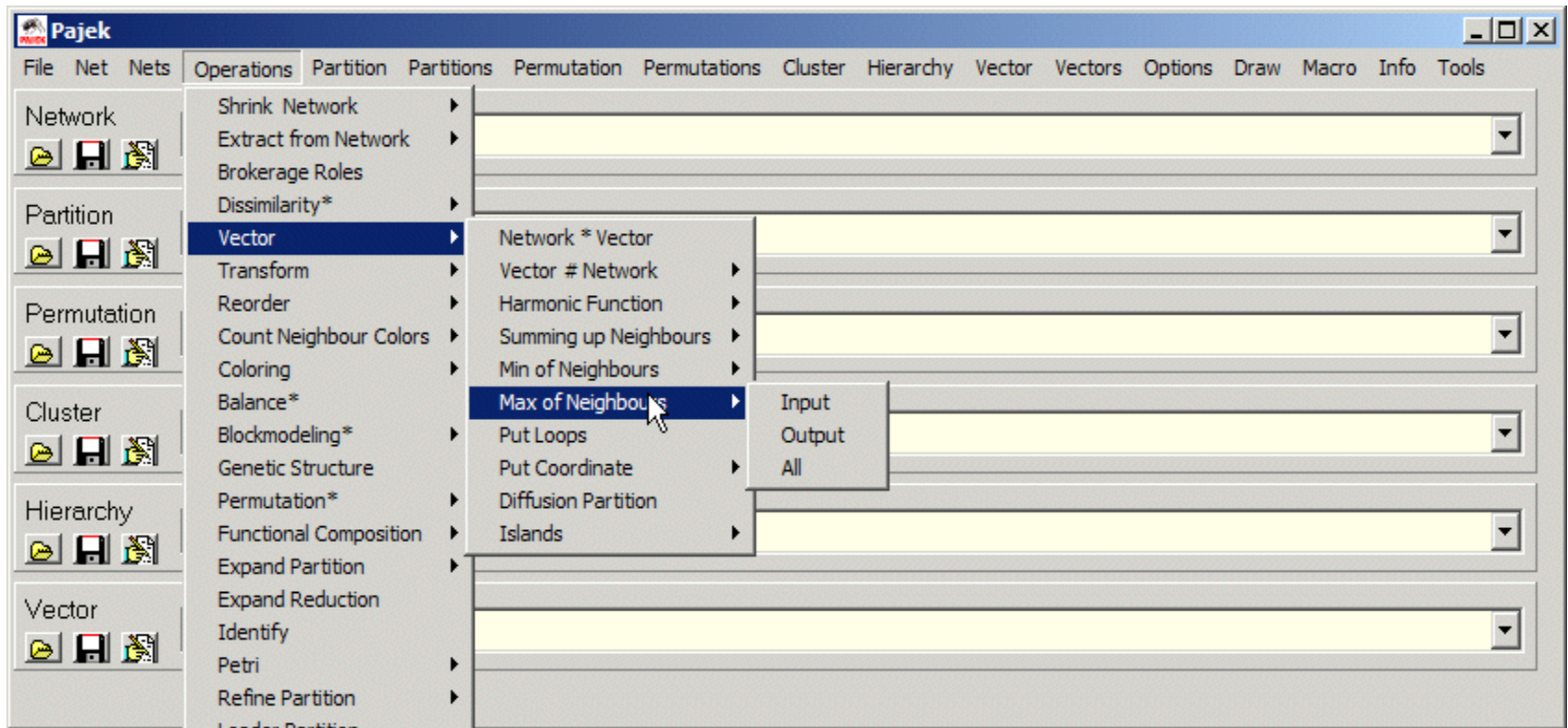
```
digraph world {
size="7,7";
{rank=same; S8 S24 S1 S35 S30;}
{rank=same; T8 T24 T1 T35 T30;}
{rank=same; 43 37 36 10 2;}
{rank=same; 25 9 38 40 13 17 12 18;}
{rank=same; 26 42 11 3 33 19 39 14 16;}
{rank=same; 4 31 34 21 41 28 20;}
{rank=same; 27 5 22 32 29 15;}
{rank=same; 6 23;}
{rank=same; 7;}
```

```
S8 -> 9;
S24 -> 25;
S24 -> 27;
S1 -> 2;
S1 -> 10;
S35 -> 43;
S35 -> 36;
S30 -> 31;
S30 -> 33;
9 -> 42;
9 -> T1;
25 -> T1;
25 -> 26;
27 -> T24;
2 -> { 3 ; 16 ; 17 ; T1 ; 18 }
10 -> { 11 ; 14 ; T1 ; 13 ; 12 ; }
31 -> T1;
31 -> 32;
33 -> T30;
33 -> 34;
42 -> 4;
26 -> 4;
3 -> 4;
16 -> 15;
17 -> 19;
18 -> 29;
11 -> 4;
14 -> 15;
37 -> { 39 ; 41 ; 38 ; 40 ; }
13 -> 19;
12 -> 29;
```



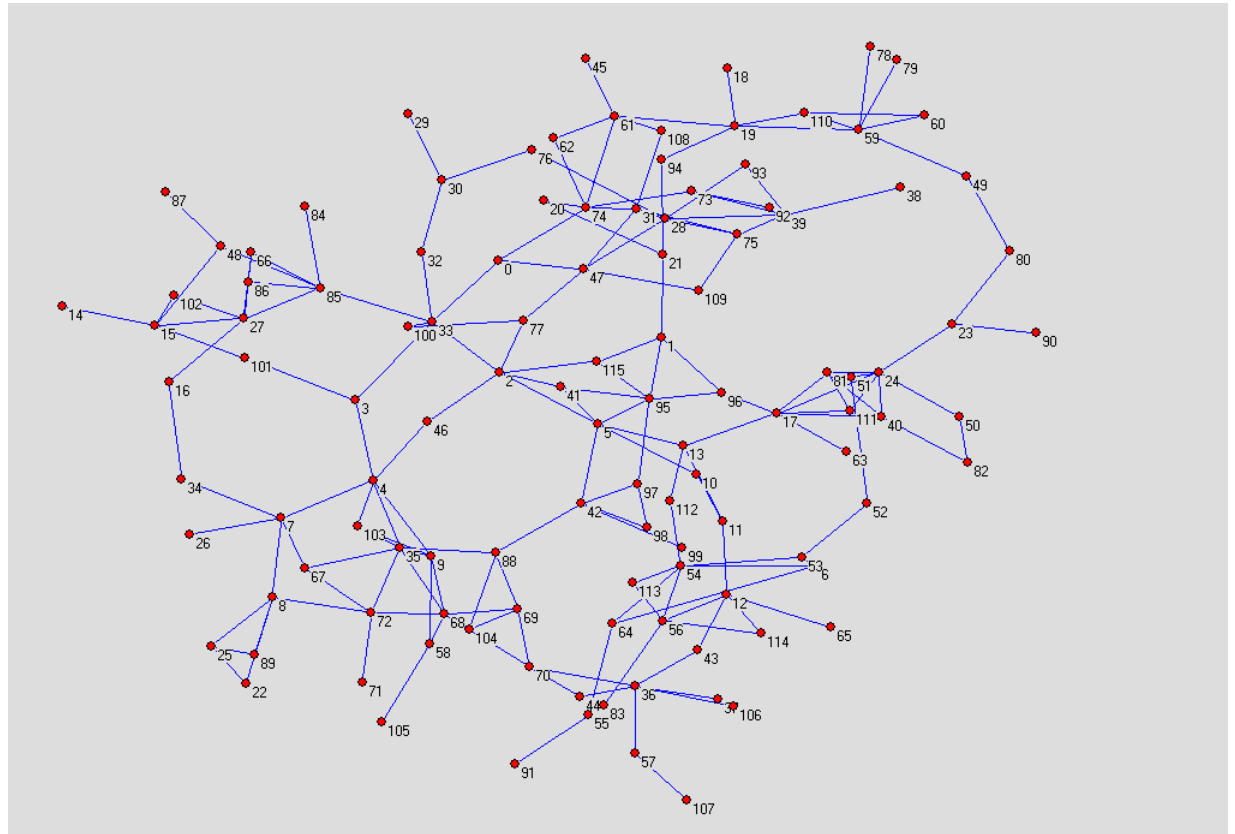
Pajek

Windows program for visualization and analysis of large networks



Pajek input and output

```
*Vertices 116
1 "0" ic Black
2 "1" ic Black
3 "2" ic Black
4 "3" ic Black
5 "4" ic Black
...
116 "115" ic Black
*Edges
1 34
1 48
2 96
2 97
2 116
3 6
3 42
3 47
3 78
3 116
4 5
4 34
4 102
5 8
5 10
5 47
6 11
6 42
7 55
7 65
8 9
8 68
11 12
12 13
14 6
...
```

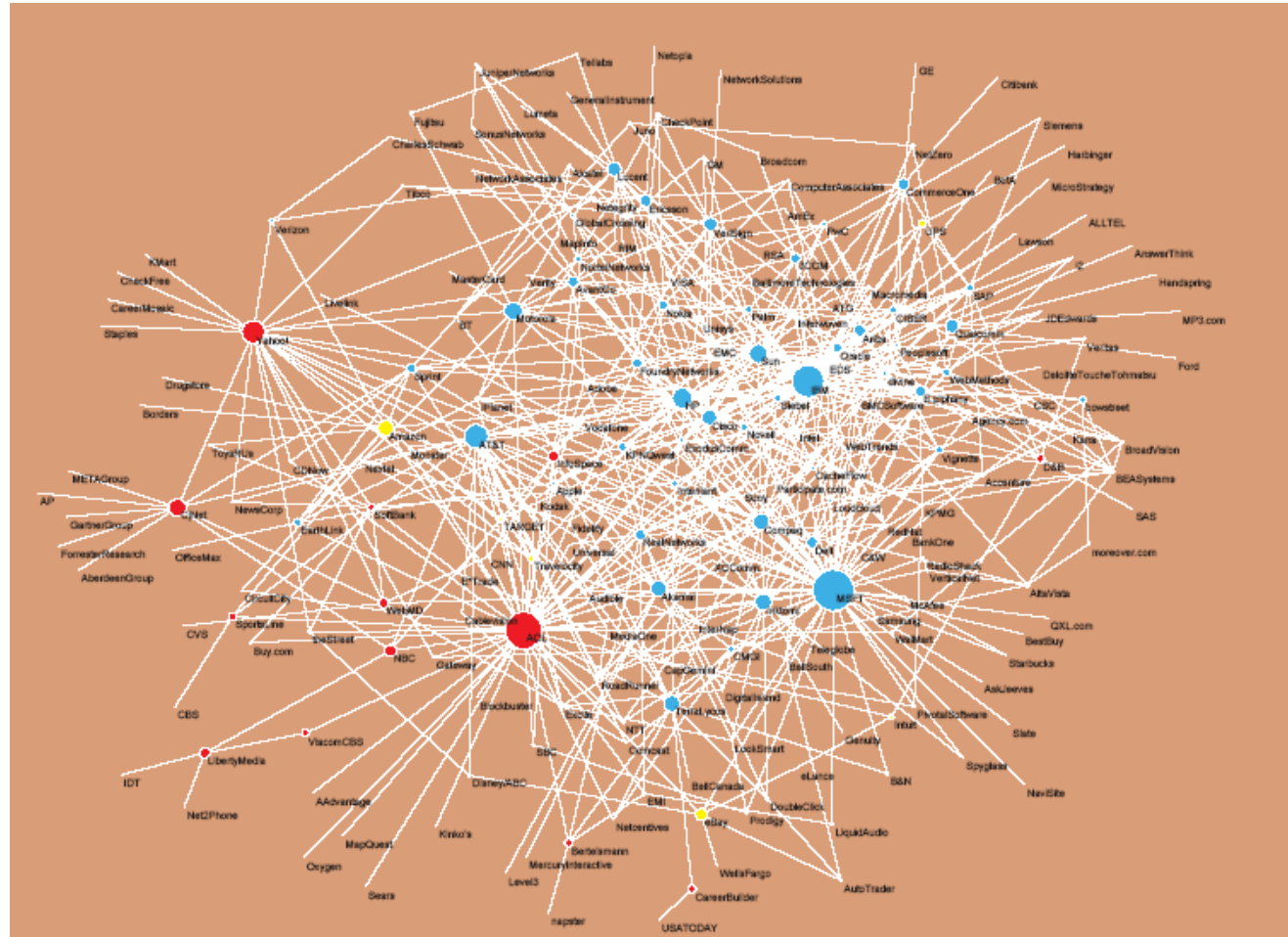


Basic layout circular, easy to change to energy-minimizing layout.

More sophisticated Pajek example: strategic alliances among companies

red - content,
blue - infrastructure
yellow – commerce

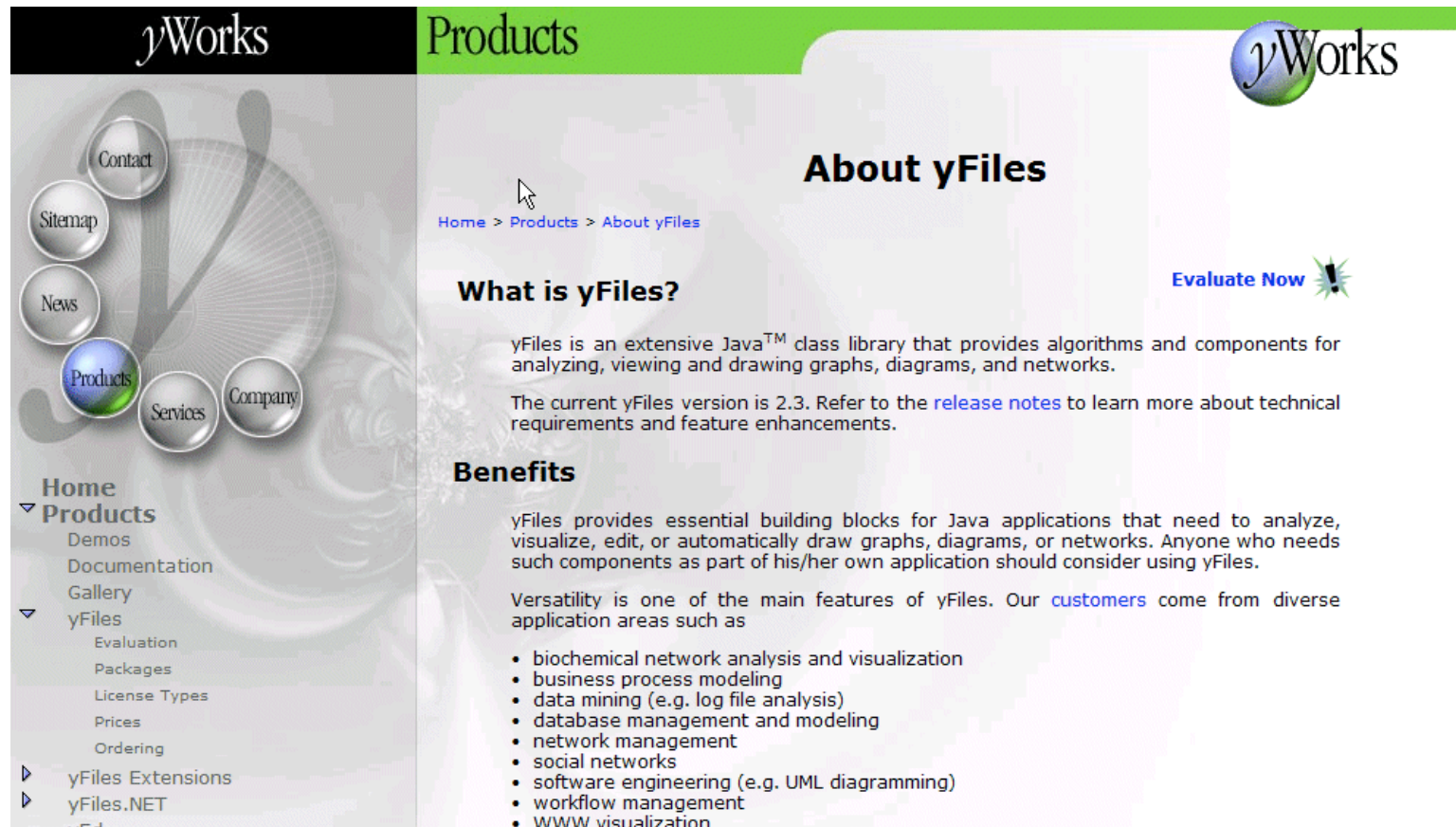
Figure by
Valdis Krebs



yED - yFiles

yED (editor) is free but yFiles costs \$\$\$

<http://www.yworks.com>



The screenshot shows the yWorks website with a green header bar. The left sidebar contains a navigation menu with links to Home, Products, yFiles, yFiles Extensions, and yFiles.NET. The main content area is titled 'About yFiles' and includes a breadcrumb trail: Home > Products > About yFiles. The text describes yFiles as a Java class library for graph visualization and lists various application areas such as biochemical network analysis, business process modeling, data mining, database management, network management, social networks, software engineering, workflow management, and WWW visualization. A 'Evaluate Now' button with an exclamation mark icon is also visible.

yWorks Products **yWorks**

About yFiles

[Home](#) > [Products](#) > [About yFiles](#)

What is yFiles?

[Evaluate Now](#) !

yFiles is an extensive Java™ class library that provides algorithms and components for analyzing, viewing and drawing graphs, diagrams, and networks.

The current yFiles version is 2.3. Refer to the [release notes](#) to learn more about technical requirements and feature enhancements.

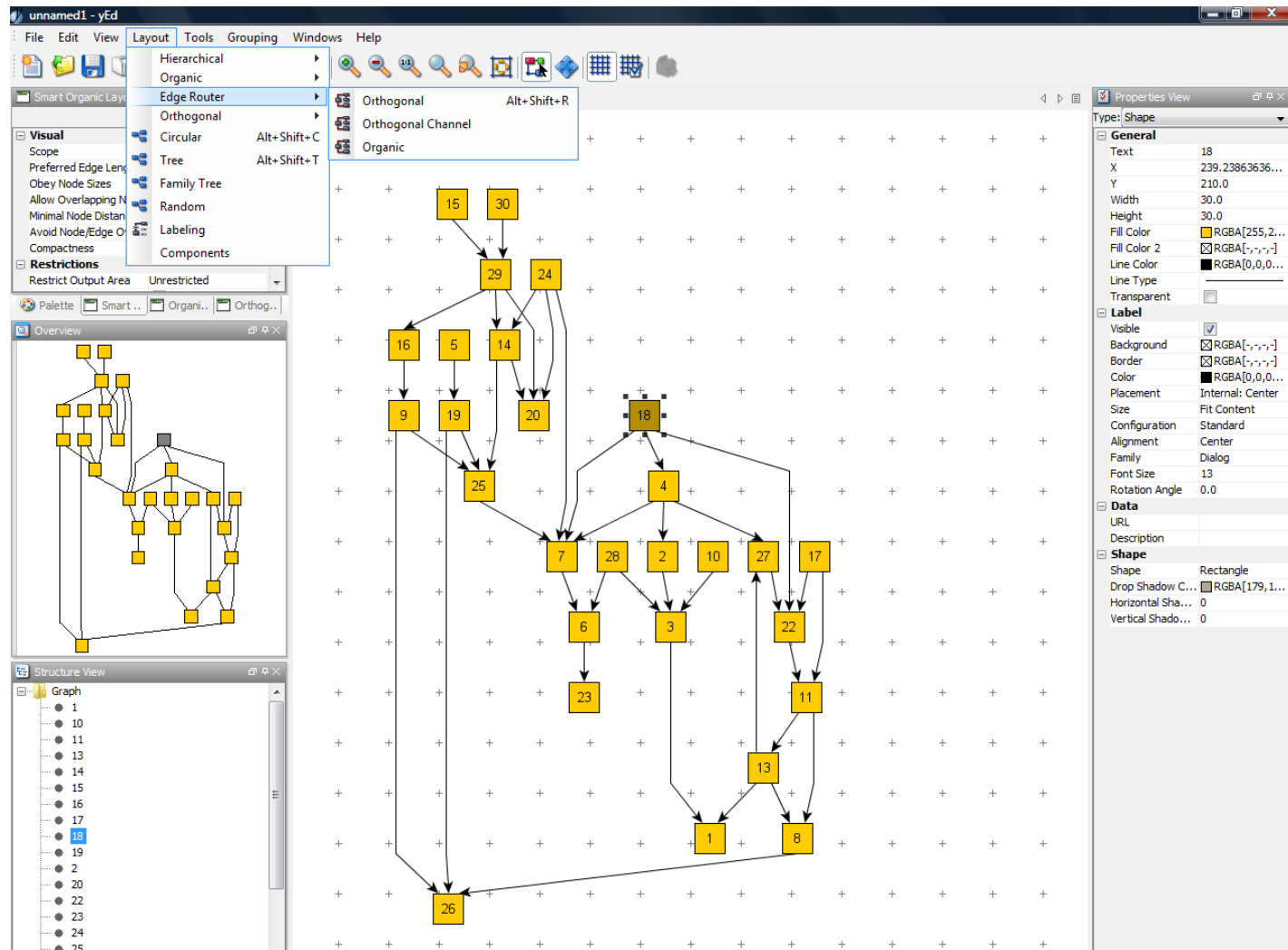
Benefits

yFiles provides essential building blocks for Java applications that need to analyze, visualize, edit, or automatically draw graphs, diagrams, or networks. Anyone who needs such components as part of his/her own application should consider using yFiles.

Versatility is one of the main features of yFiles. Our [customers](#) come from diverse application areas such as

- biochemical network analysis and visualization
- business process modeling
- data mining (e.g. log file analysis)
- database management and modeling
- network management
- social networks
- software engineering (e.g. UML diagramming)
- workflow management
- WWW visualization

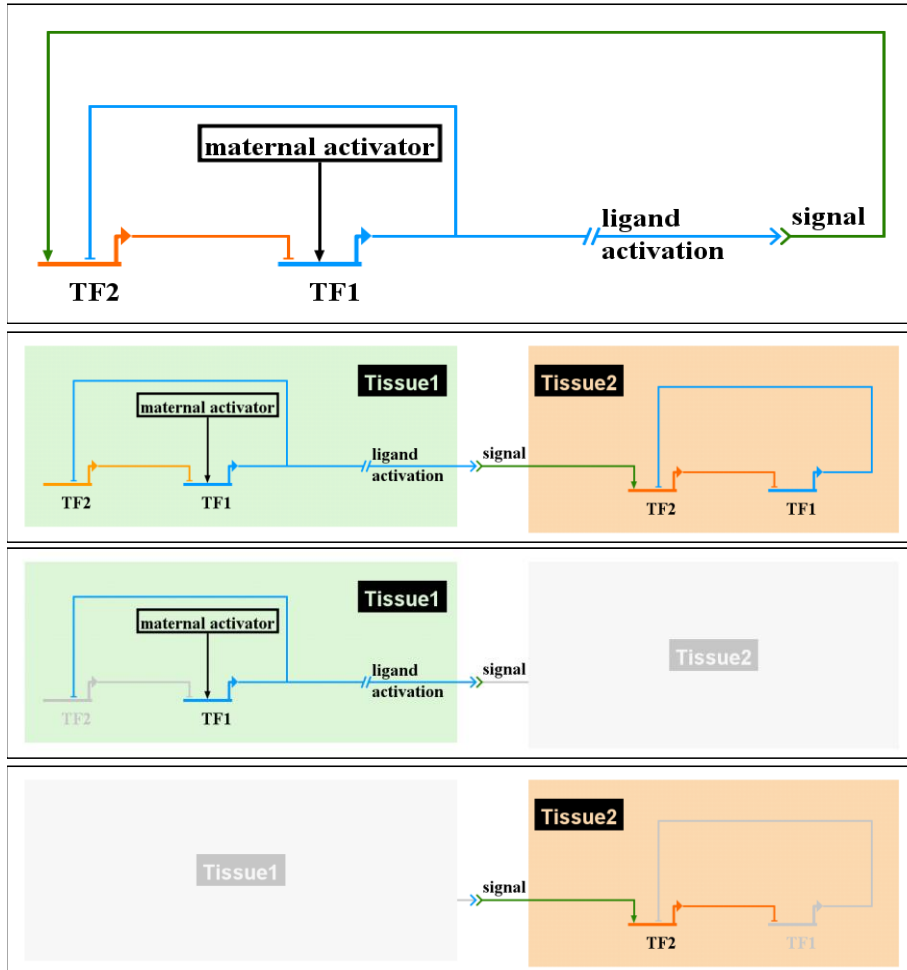
yED – Excellent Layout



BioTapestry

<http://www.biotapestry.org/>

Used in our textbook, read Chapter 5



View from the genome: one copy of each node, shows all the interactions.

View from all nuclei: shows the regulatory relationships among the same network in different compartments.

View from nucleus (tissue) 1. Grey means inactive.

View from nucleus (tissue) 2.

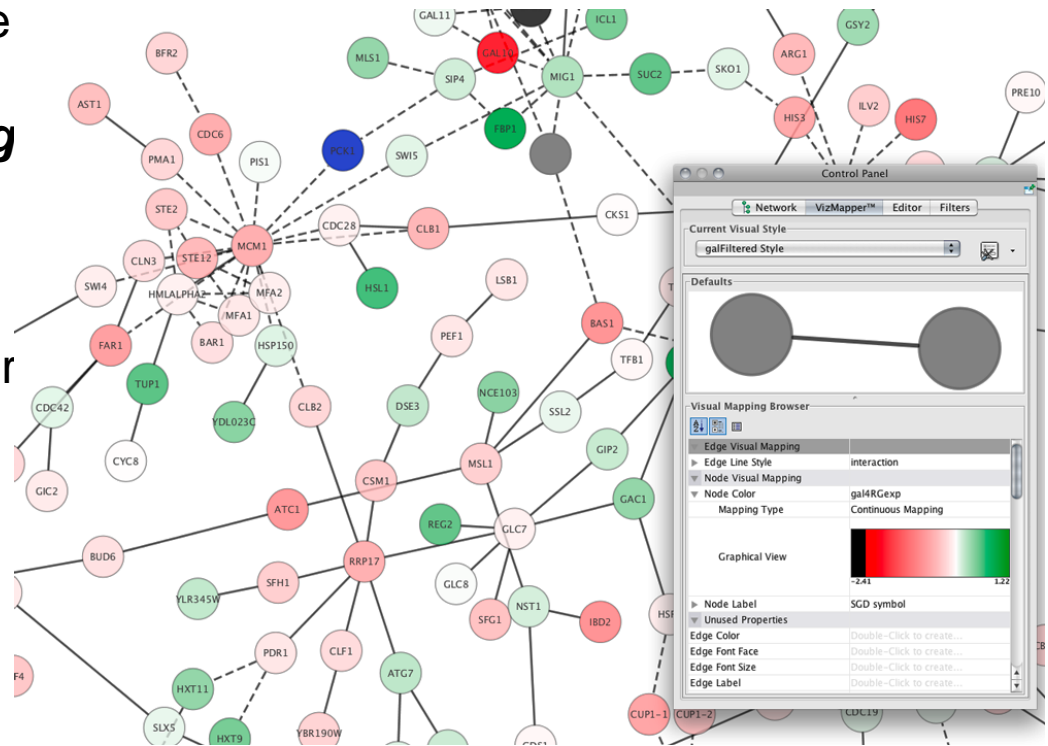
Cytoscape – biology oriented

<http://www.cytoscape.org/>

Open source bioinformatics software platform for **visualizing** molecular interaction networks and **integrating** them with annotations, gene expression profiles and other state data.

Cytoscape *core* provides features for data integration and visualization.

Plugins are available for network and molecular profiling analyses, new layouts, scripting, and connection with databases.



Python – Networkx graph library

Uses Graphviz for graph visualization

NetworkX

[NetworkX Home](#) | [Search](#) | [Download](#) | [Developer Site](#) | [Documentation](#) » [modules](#) | [index](#)

This documentation is currently being updated for release 0.99 of NetworkX. This update includes significant changes to the underlying Graph and DiGraph objects to reflect our common use case of weighted graphs and to improve performance. See the [API changes](#) for detailed information.

High productivity software for complex networks

NetworkX is a Python package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks.

Quick Example

```
>>> import networkx as nx
>>> G=nx.Graph()
>>> G.add_edge(1,2)
>>> G.add_node("spam")
>>> print G.nodes()
[1, 2, 'spam']
>>> print G.edges()
[(1, 2)]
```

Documentation

[Tutorial](#)
start here

[Reference](#)
guide to all functions and classes

[Examples](#)
using the library

[Gallery](#)
network drawings

[Contents](#)
a complete overview

[Search Page](#)
search the documentation

[General Index](#)
all functions, classes, terms

[Module Index](#)
quick access to all documented modules

Download

Current version: **0.99**

Get NetworkX from the [Python Package Index](#), or install it with:

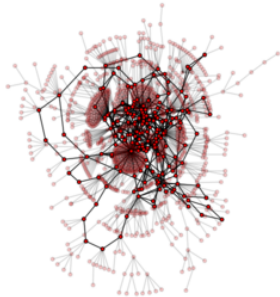
`easy_install networkx`

Questions? Suggestions?

Join the [Google group](#):

You can also open an issue at the on the [developer's site](#).

Quick search



A networkx example

```
2 import networkx as nx
3
4 # generate a few different types of random graphs
5 er = nx.erdos_renyi_graph( 100, 0.1 )
6 ws = nx.watts_strogatz_graph ( 100, 10, 0.2 )
7 ba = nx.barabasi_albert_graph( 100, 2 )
8
9 # collect them in a list
10 allgen = [ er, ws, ba ]
11
12 # print various network measures
13 for graph in allgen:
14     avg = nx.cluster.average_clustering( graph )
15     diam = nx.distance.diameter( graph )
16     cent = nx centrality.betweenness centrality(graph)
17     print 'Avg=%4.2f, Diameter=%s, BCentral=%s' % (avg, diam, cent)
18
```



```
Avg=0.10, Diameter=4, BCentral={0: 0.016015371933121809, 1: 0.0039172788090537005,
Avg=0.39, Diameter=4, BCentral={0: 0.037242946115432697, 1: 0.023804532988251741, 2:
Avg=0.15, Diameter=6, BCentral={0: 0.17685572133217217, 1: 0.0, 2: 0.29895977927013
```


igraph software library

The igraph library						sourceforge
Home	News	Download	Documentation	Wiki	Screenshots	Mailing lists
Bugs	License					

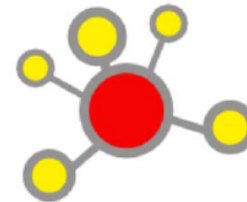
Introduction

igraph is a free software package for creating and manipulating undirected and directed graphs. It includes implementations for classic graph theory problems like minimum spanning trees and network flow, and also implements algorithms for some recent network analysis methods, like community structure search.

The efficient implementation of **igraph** allows it to handle graphs with millions of vertices and edges. The rule of thumb is that if your graph fits into the physical memory then **igraph** can handle it.

igraph can be installed in several forms:

- **igraph** as a *C library* is useful if you want to use it in your C/C++ projects, or want to implement your own network analysis or model in C/C++ using the data structures and functions **igraph** provides.
- **igraph** as an *R package*. You can use **igraph** as an extension package to [The GNU R project for Statistical Computing](#). The flexibility of the R language and its richness in statistical methods add a great deal of productivity to **igraph**, with a very small speed penalty.
- **igraph** as a *Python* extension module. This way you can combine **igraph** with the huge set of Python functions and modules available, and the ease of the Python language, with a small speed penalty.
- **igraph** as a *Ruby* extension. If you like the Ruby language, then this might be the right choice for you.



Latest version: 0.5.2

[Release notes](#)

JUNG (Java Universal Network/Graph Framework) software library

<http://jung.sourceforge.net/index.html>

- Written in Java, open-source
- Graph visualization with several basic layouts
- Calculates main graph measures
- Graph algorithms: clustering, connectivity, maximum flow, PageRank

